

A!

Aalto University



The End-Use Performance of Sustainable Fuels, Current Accomplishments, and Future Scope

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Energy Breakfast | Take-Off Time for Biofuels: A Sustainable Future for Aviation?

Agenda

- Motivation
- Aviation – climate targets
- How to decarbonize aviation?
- The role of EC group (A!) in development of sustainable aviation.
- ADVANCEFUEL project
- Some part of results
- Conclusions



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Map of the World's Air Traffic Connections



1937

Map of the World's Air Traffic Connections

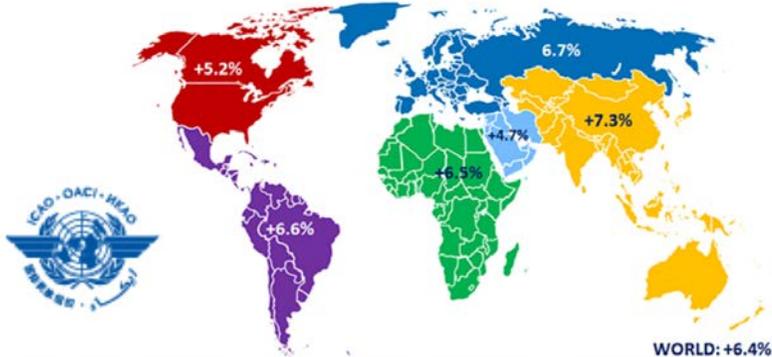


- >3 billion passengers
- 1400 airliners
- 4000 airports
- 25 000 airplanes

2014

Aviation is a number ONE if it comes to the growth!

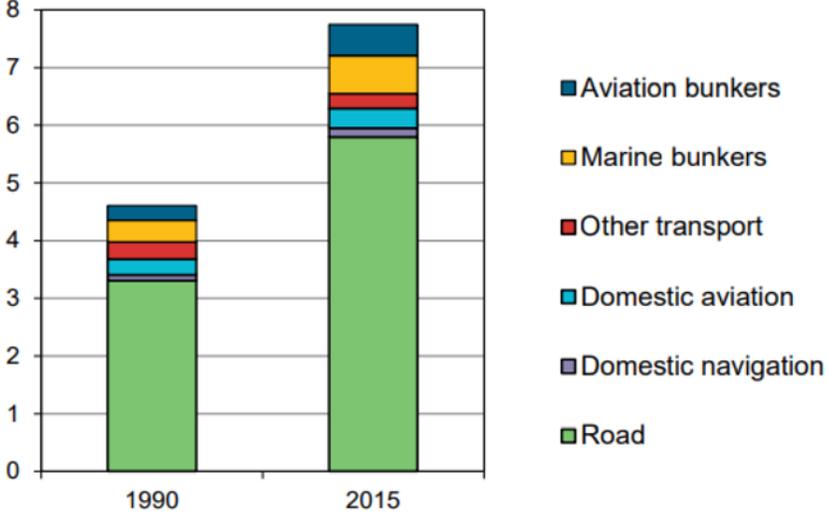
International Civil Aviation Organization (ICAO)
Solid passenger traffic growth and moderate air cargo demand in 2018



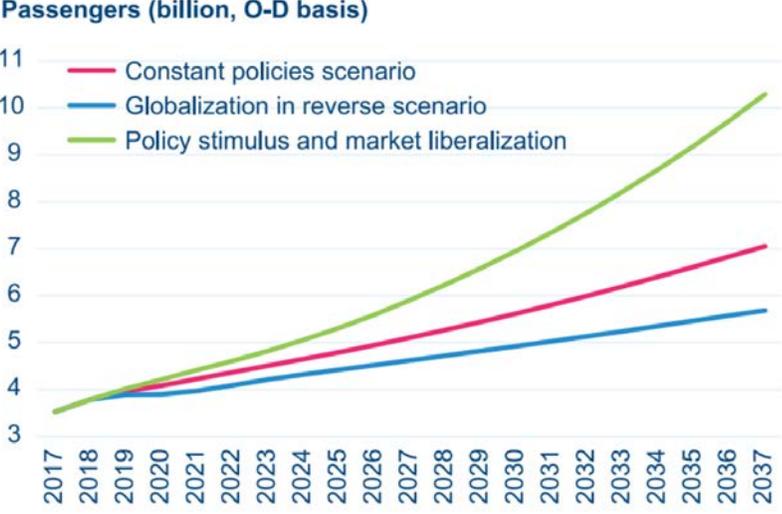
Preliminary figures released today by ICAO showing international scheduled revenue passenger-kilometres (RPK) growth in 2018.



GtCO₂



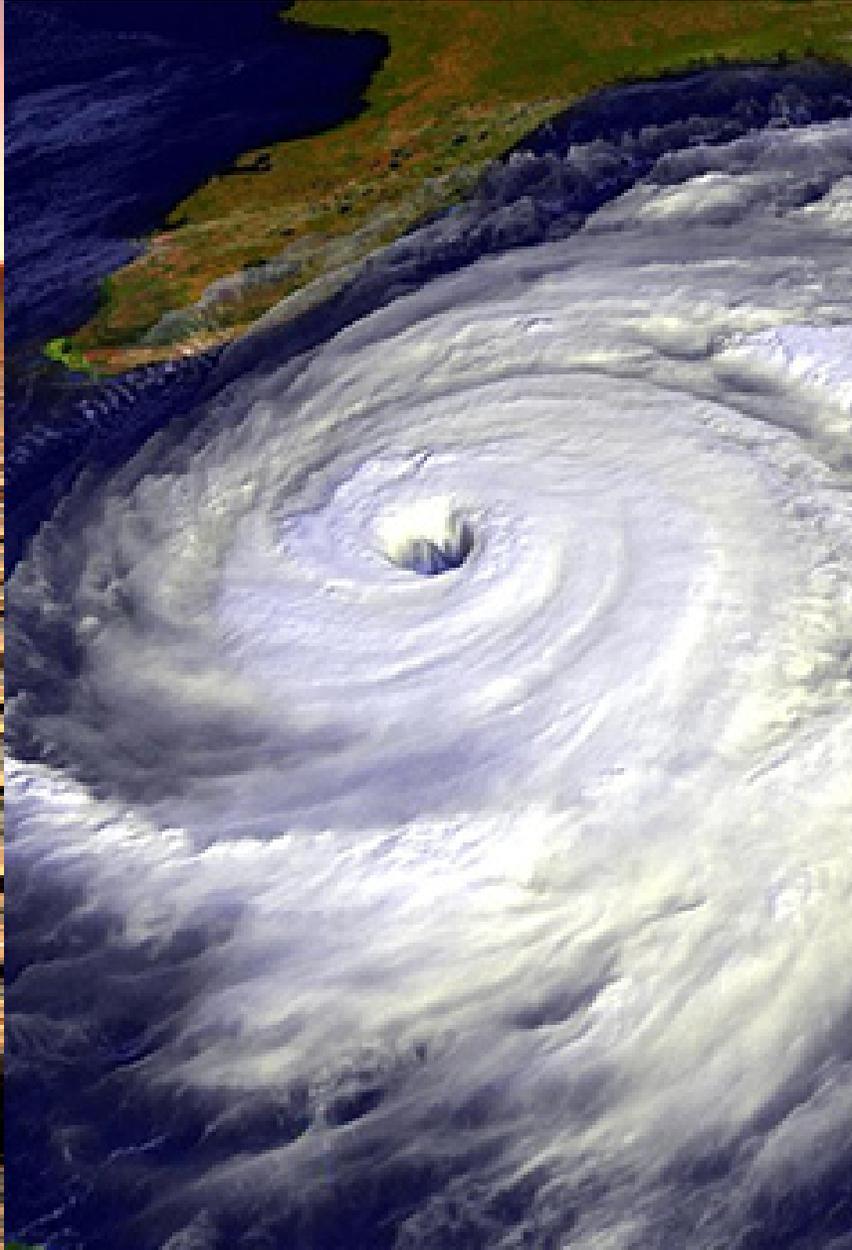
International Energy Agency. CO₂ Emissions from Fuel Combustion 2017.



Sources: IATA/ITE

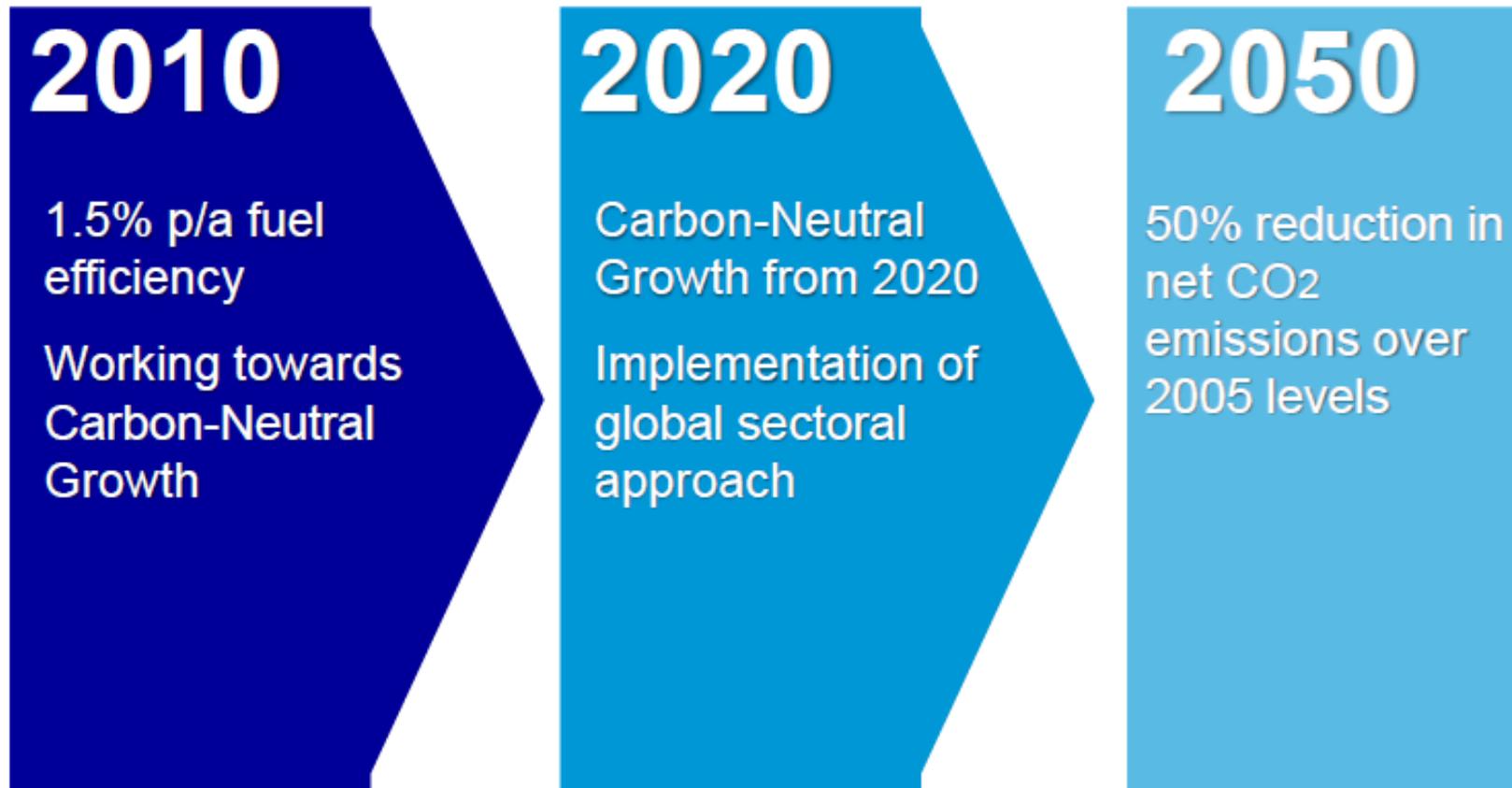


Are we not in trouble?

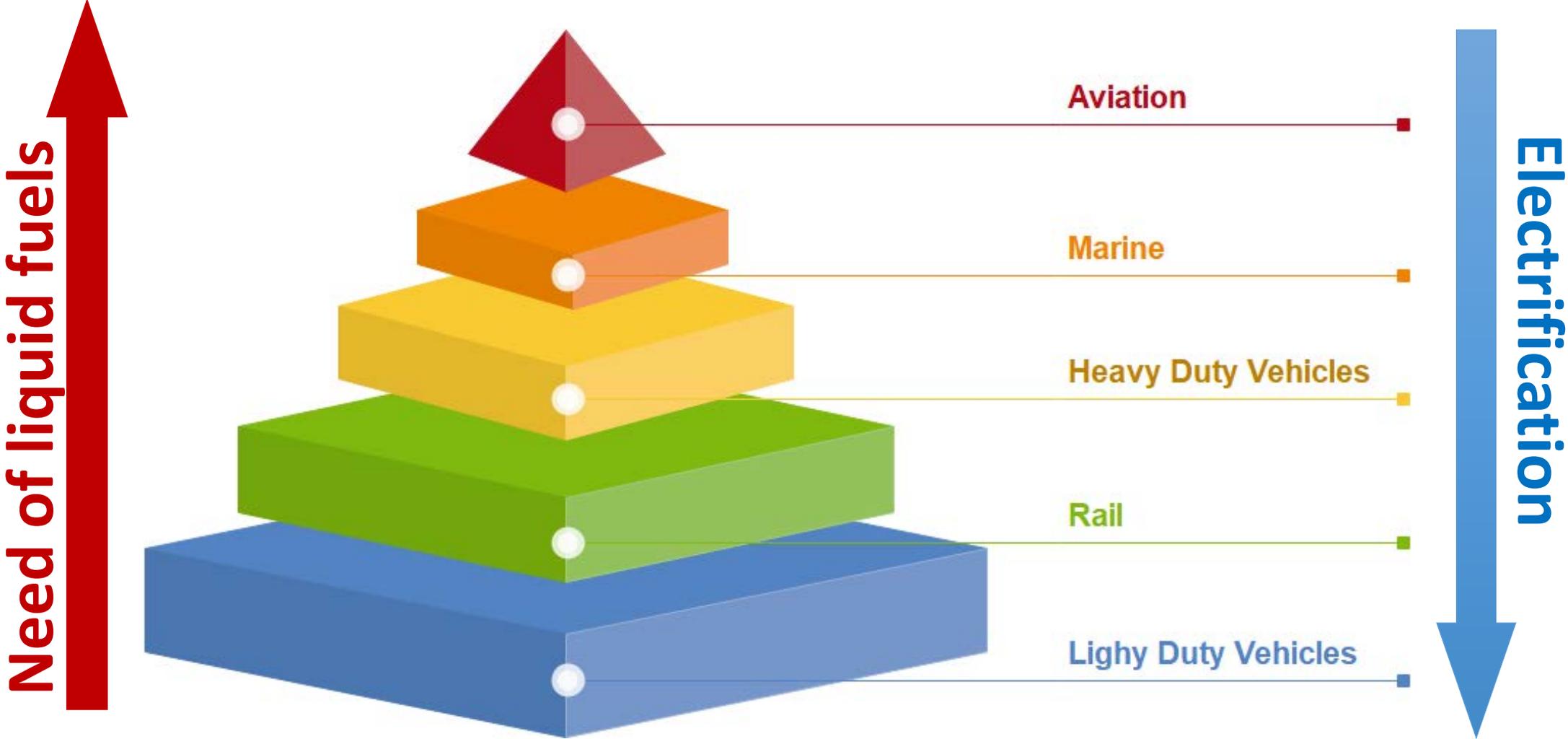


Aviation - sector specific targets

In 2009, the aviation industry collectively agreed to the world's first set of sector-specific climate change targets.



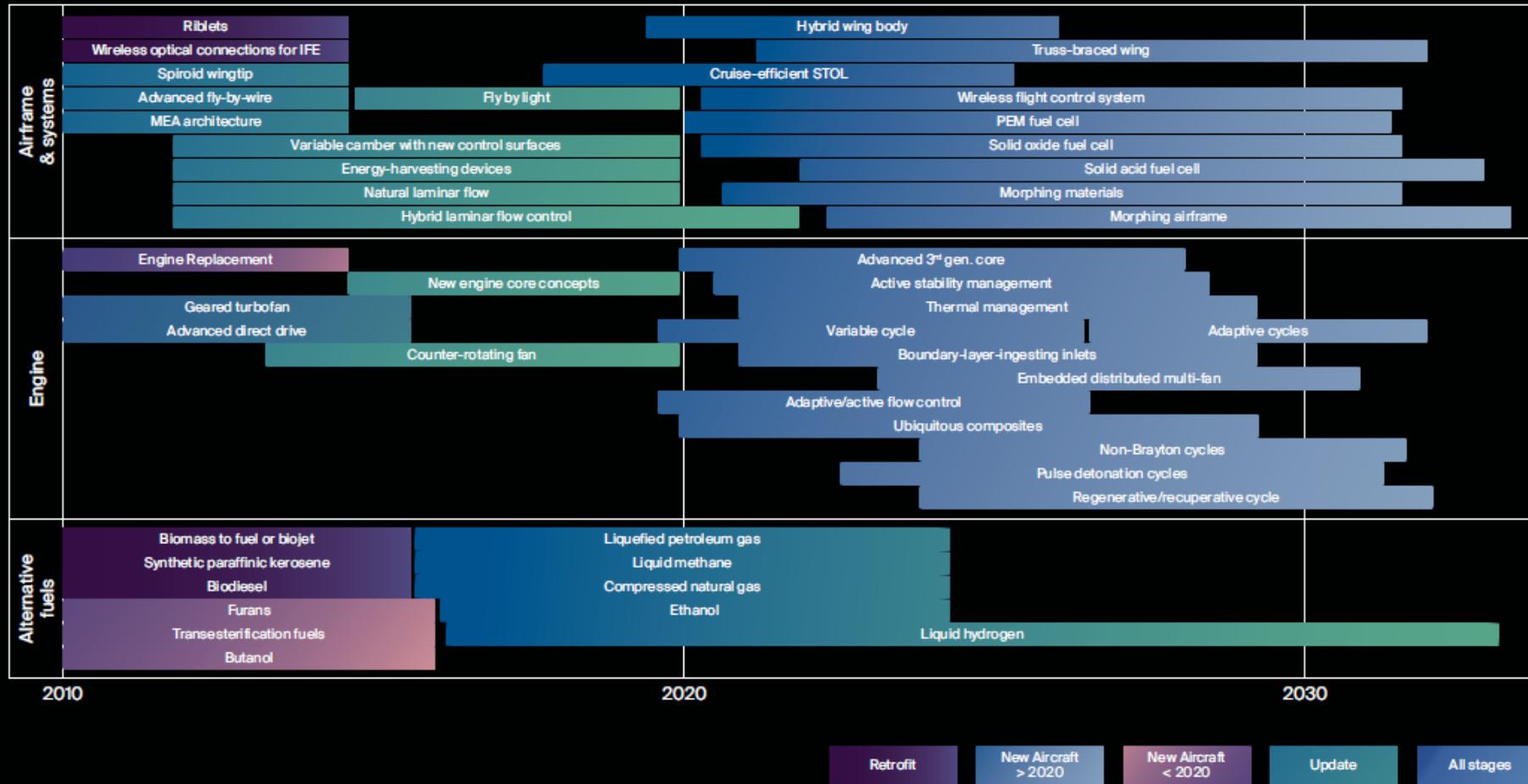
Need of liquid fuels vs electrification



Technology Advancements

Incremental improvements in technology are more frequent than clean-sheet designs

Technological breakthroughs are one of the key market drivers of the air transport industry. The IATA Technology Roadmap suggests that there will be several incremental improvements in the airframe and engine manufacturing domains.



Past and future ASTM certifications of SAF production pathways



			Blending
CERTIFIED	Fischer-Tropsch (any feedstock)	2009	50%
	HEFA (vegetable oils, animal fats)	2011	50%
	Synthetic Iso-paraffin (direct sugar) (SIP)	2014	10%
UNDER REVIEW	Alcohol-to-Jet	exp. 2015	
	FT synthetic paraffinic kerosene with aromatics (SKA)	exp. 2016	
	Hydroprocessed depolymerized cellulosic jet	exp. 2016	
TESTING	Alcohol to jet SKA		
	Catalytic hydrothermolysis		
	Synthetic aromatic kerosene by catalytic conversion of sugars		
	Synthetic (paraffinic) kerosene by catalytic conversion of sugars		

HEFA - Hydrotreated Esters and Fatty Acids

Close collaboration within the whole value chain and beyond!



<https://blogs.scientificamerican.com/guest-blog/how-international-cooperation-in-research-advances-both-science-and-diplomacy/>

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- ❑ Part of EU Horizon 2020
- ❑ Coordination and Support Action of EU Commission
- ❑ Facilitating market roll-out of advanced liquid biofuels in transportation sector between 2020 and 2030 and beyond

Partners:



Chalmers University
of Technology
Sweden



Greenovate! Europe
Belgium



ATB - Leibniz Institute
for Agricultural Engineering
and Bioeconomy
Germany



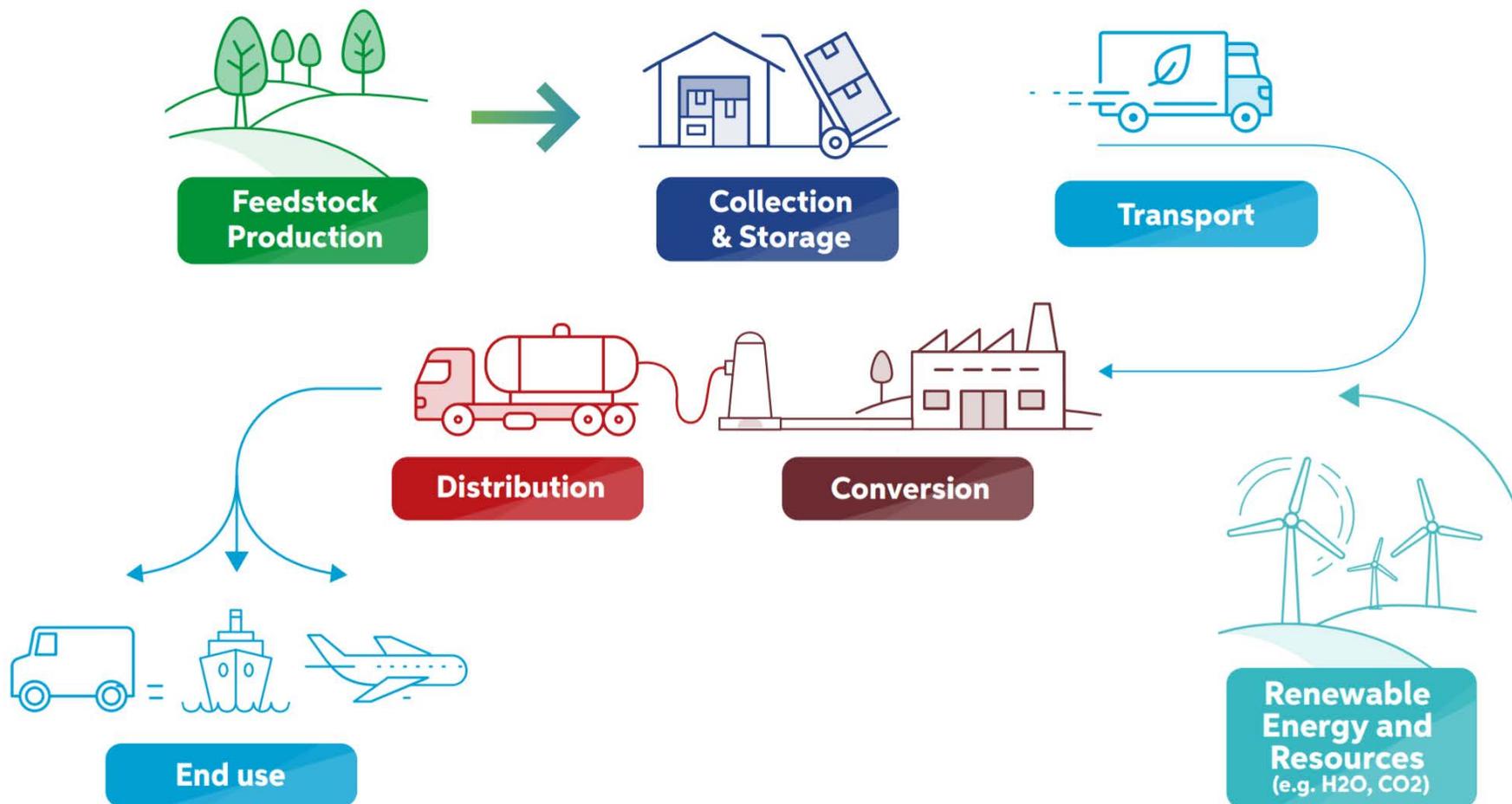
Aalto University
Finland

Stakeholders:





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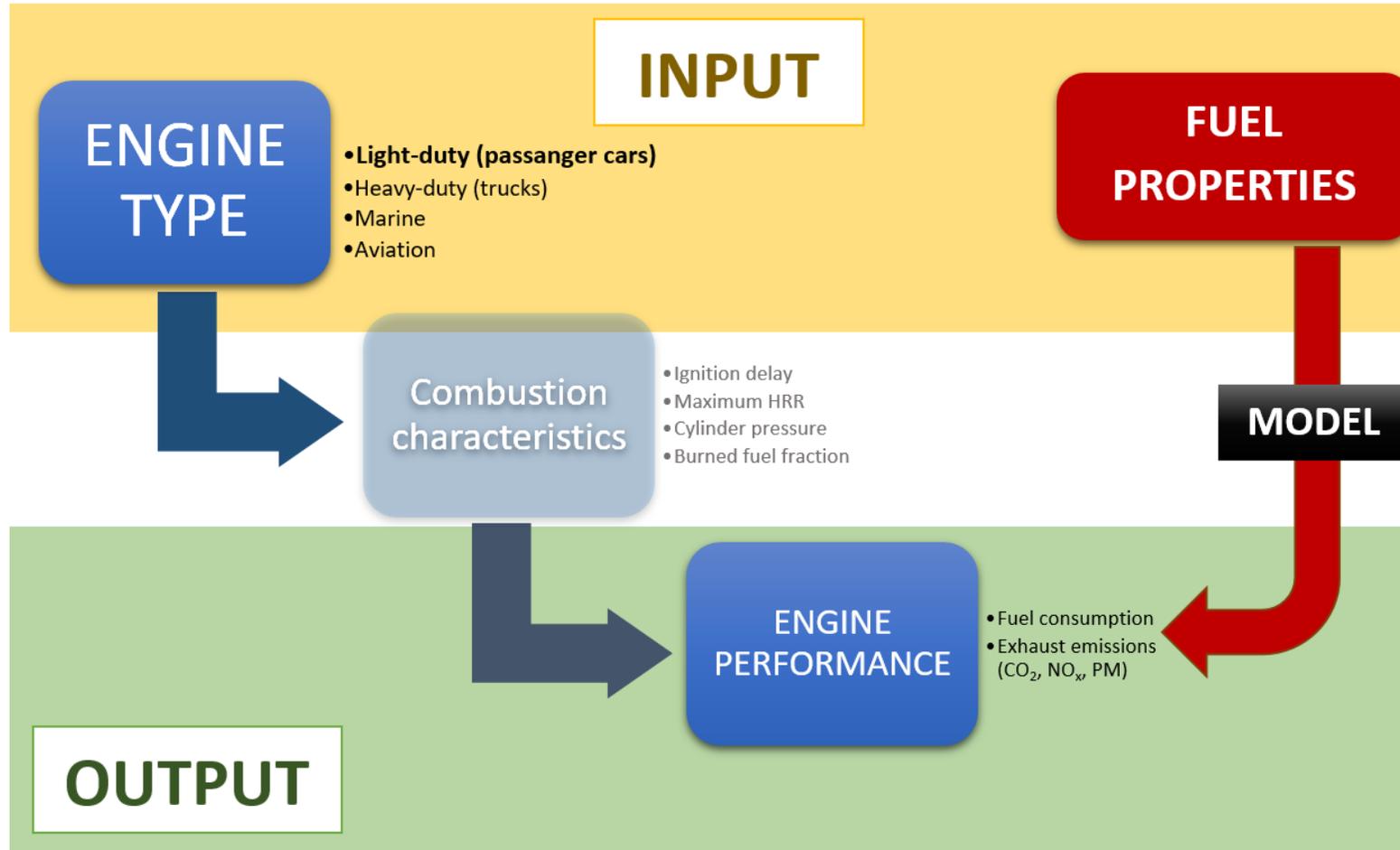
Importance of the research

- Increased market acceptance and end-use of renewable fuels
- Support for decision makers and fuel producers
- Assessment of future potential of alternative fuels
- *Providing market stakeholders with state-of-art knowledge and sophisticated, user-friendly tools with integrated calculators, standards, and recommendations.*

Structure of the problem



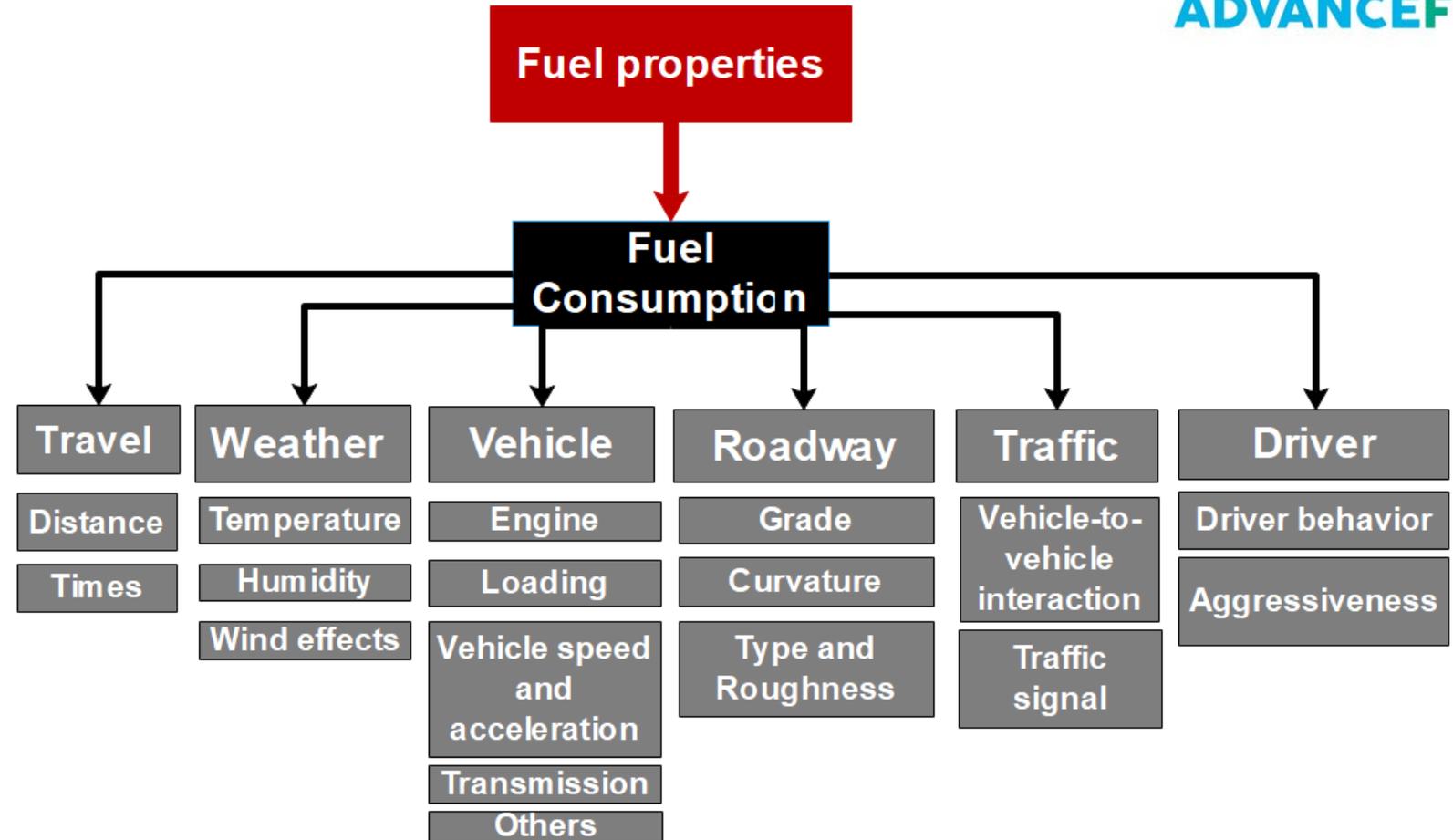
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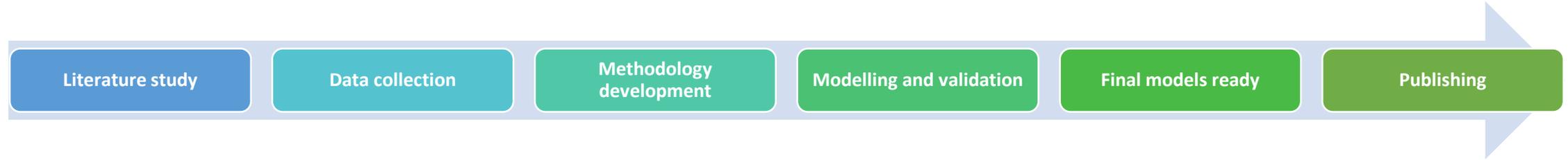


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The novelty of the studies



Current Accomplishments, and Future Scope



Road

- SI LDV - Published
- CI LDV - Published
- SI HDV - data collection
- CI HDV – data collection



Off-road

- SI engines - data collection
- CI engines – data collection



Marine

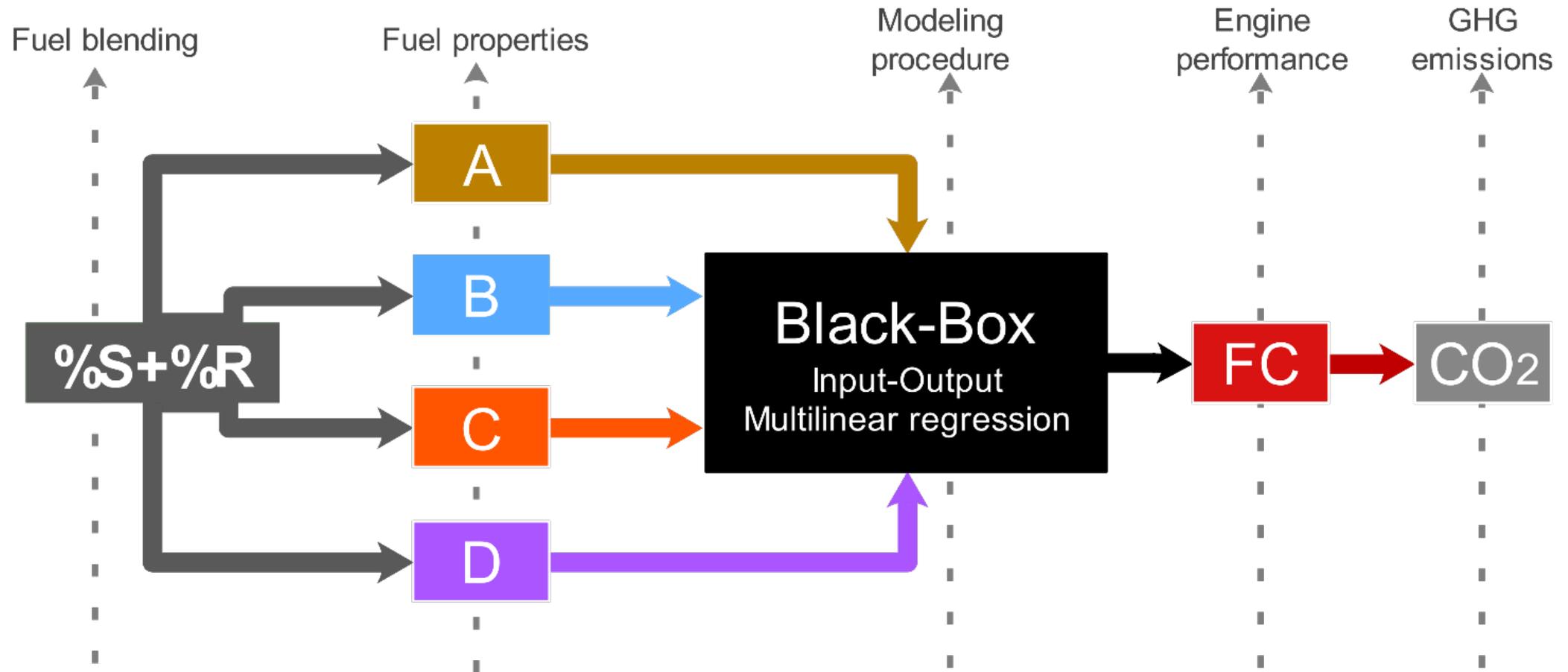
- Model published



Aviation

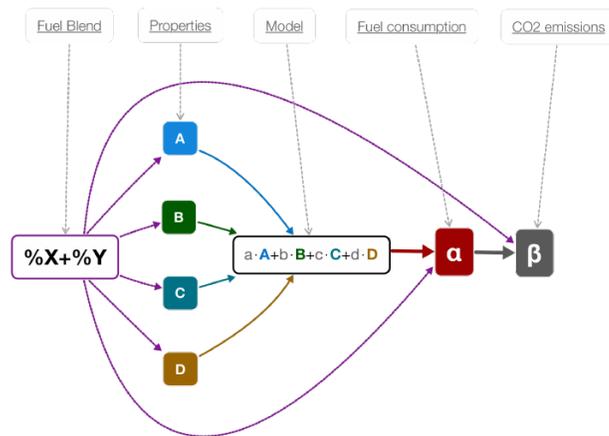
- Data collection
- Methodology development

Approach to the research problem



Modeling methodology

- Character of the data: **multi input, single output**
- Approach: **data-driven black-box modeling**
- Mathematical methodology: **multilinear regression**
- Validation: **residual analysis and cross-validation**



$$\alpha = a \cdot A(X) + b \cdot B(X) + c \cdot C(X) + d \cdot D(X)$$

α - fuel consumption [%]

X – alternative fuel concentration [%]

A(X)...D(X) – fuel property [%]

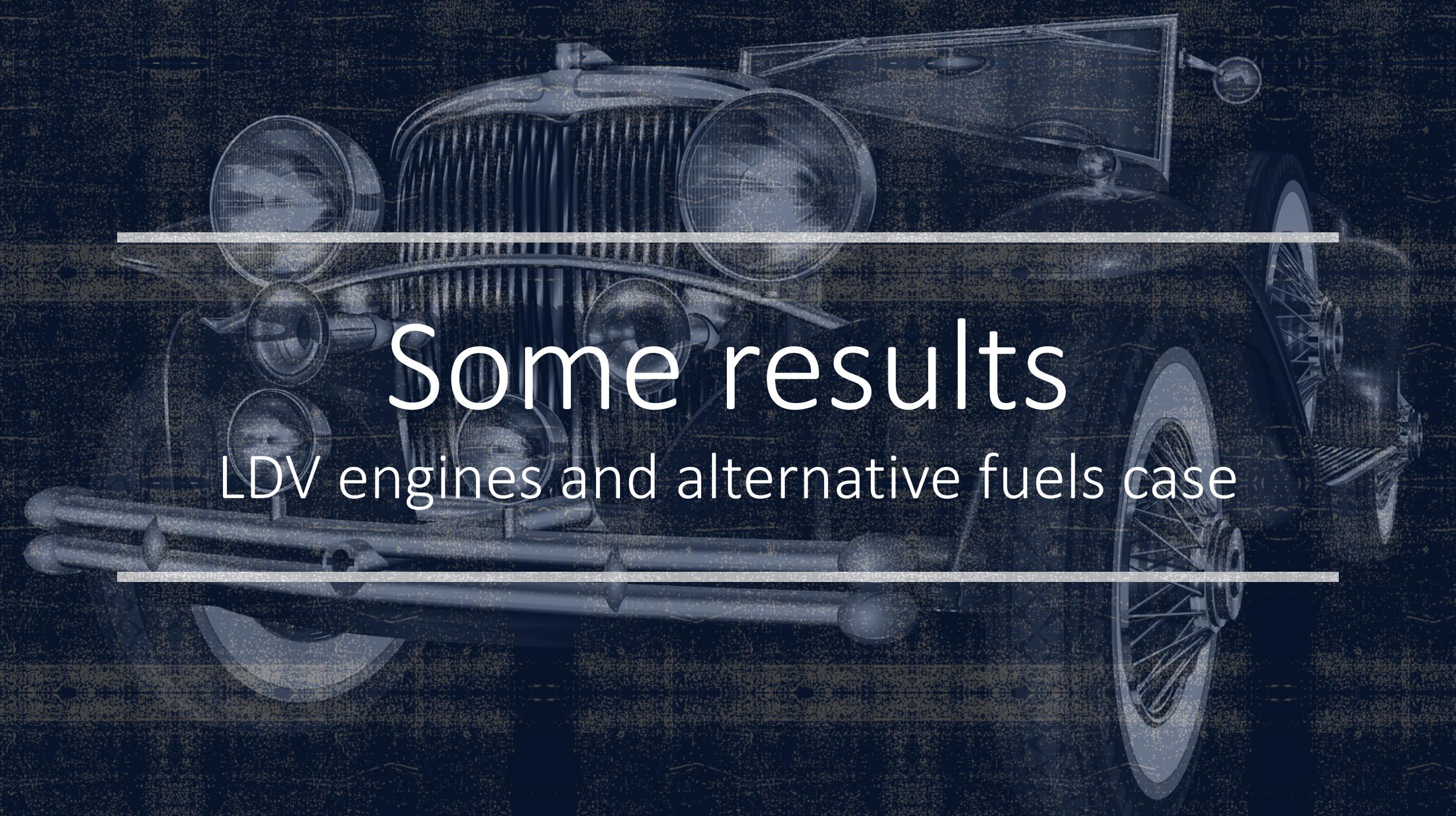
a...d – model coefficients.

- **Input and output parameters represented as relative (%) changes in reference to standard diesel/gasoline.**

How to select input properties ?

- Properties that are measured in the literature sources.
- Statistical significance analysis (t-test, p-value for t-test). All input properties have to be mathematically significant and justified.





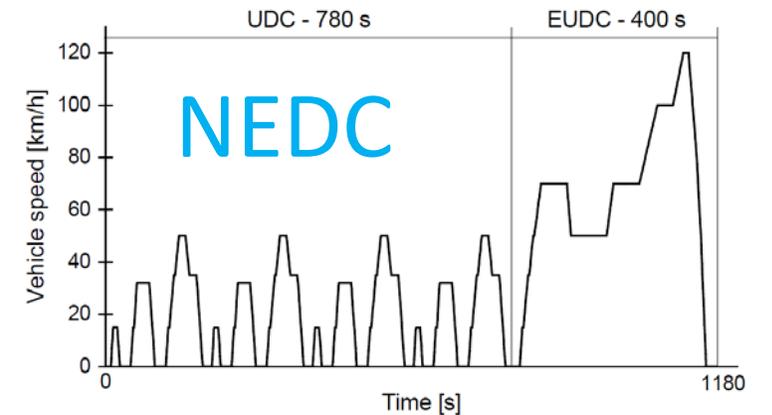
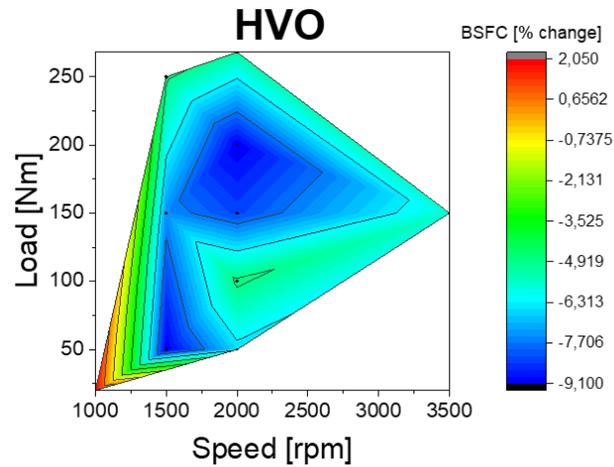
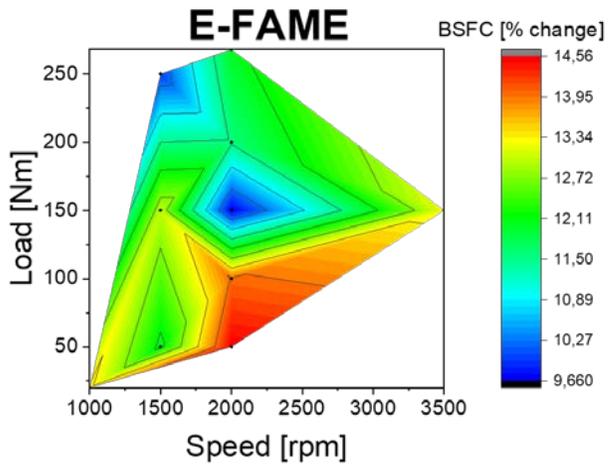
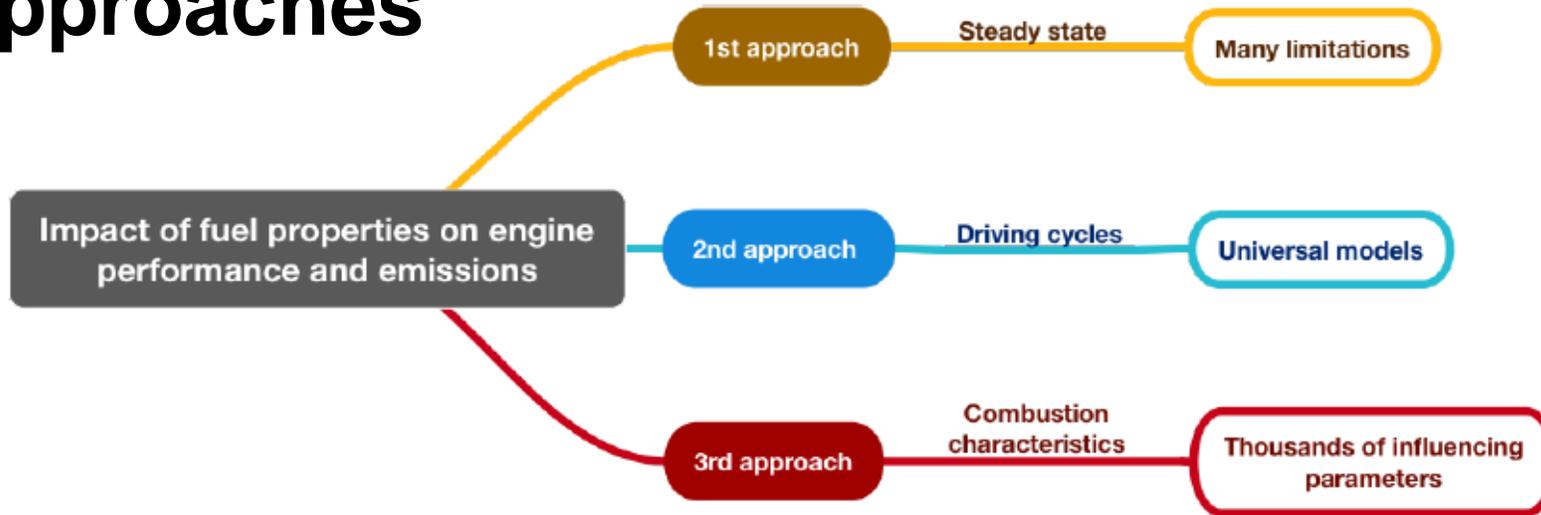
Some results

LDV engines and alternative fuels case



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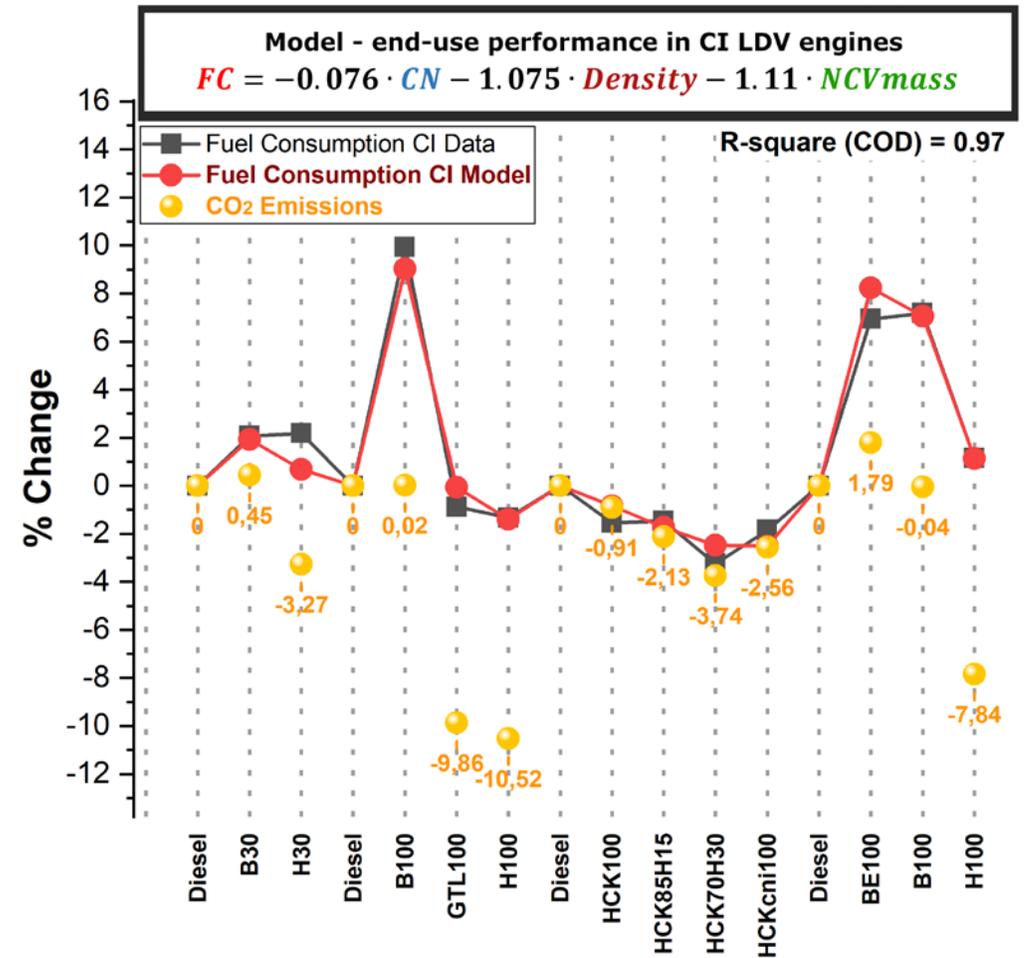
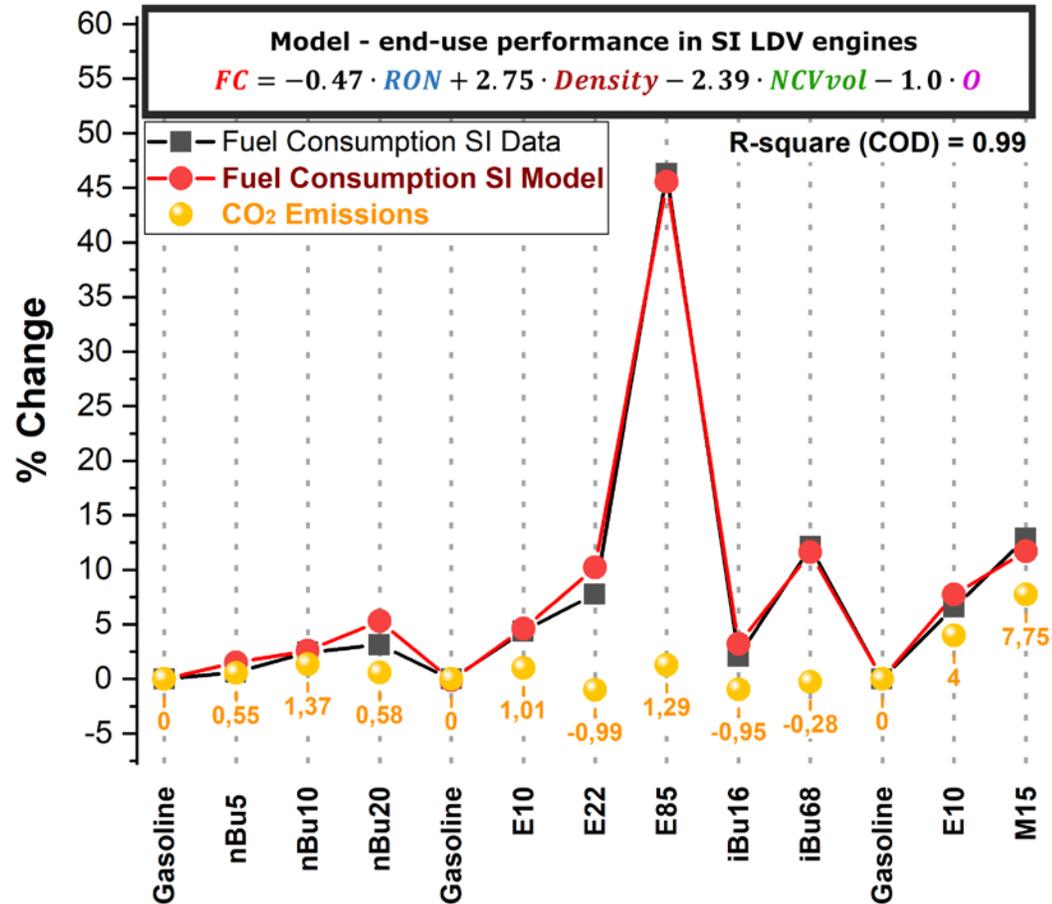
Possible approaches



End-use performance of alternative SI and CI fuels in LDV engines.



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Conclusions

- Liquid fuels will be in the high need even in the distant future.
- Aviation is the last branch of the transport sector to be electrified!
- The black-box modeling of the end-use performance of alternative transport fuels resulted in high-quality models.
- Fuel consumption of alternative fuel or its blends can be predicted based on known set of fuel properties.
- Engine performance is influenced strongly by both fuel properties and operation (driving) conditions.
- Developed models both for SI and CI case represent the impact of fuel properties on engine performance with high accuracy (FC and CO_2). However, models are under continuous development.

Time for some
good news 😊

December 2018

OVER

150 000

Flights using SAF

4 AIRPORTS

Regularly distributing SAF

Oslo (Lufthansa, KLM, SAS, KLC),

LAX (United and KLM),

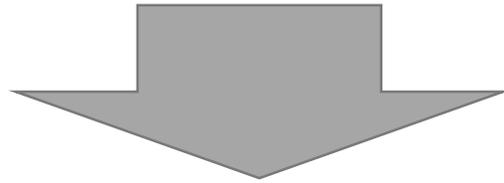
Stockholm (SAS, KLM, BRA),

Bergen (all departures).

Additionally, batches have been delivered to: Stockholm Bromma, Are Ostersund, Goteborg, Karlstad, Halmstad, Brisbane, Chicago.

42 Million Liters

Approximate amount of SAF produced in 2017



1500 Million Liters

Agreements from commercial airlines to purchase SAF in the future

Thank you for your attention !



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- Energy Conversion Research Group <https://youtu.be/mK41f24lX1k>